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## *ZOOLOGICAL PROBLEMS STUDIED BY A PSYCHOLOGIST, PSYCHOLOGICAL PROBLEMS STUDIED BY A ZOOLOGIST.*

*Animal Behaviour.* By C. Lloyd Morgan, F.R.S. Pp. viii + 344. (London: Arnold, 1900.) Price 10*s.* 6*d.*

THIS interesting and highly suggestive work grew out of an attempt to revise the author's "Animal Life and Intelligence." It was found that "the amended treatment would not fall conveniently under the previous scheme of arrangement." The subject is divided into seven sections, dealt with in as many chapters, the first concerned with "Organic Behaviour," the second "Consciousness," the third "Instinctive Behaviour," the fourth "Intelligent Behaviour," the fifth "Social Behaviour," the sixth "Feelings and Emotions," the seventh "Evolution of Animal Behaviour." The illustrations are numbered 1 to 26; but some of them contain several figures. Part of the work is coarse and unsightly, although clear (*e.g.* Fig. 13); on the other hand, some of the process blocks are quite successful, especially those which reproduce Mr. Charles Whymper's three drawings (Figs. 4, 5, 15). The book is well and clearly printed, and there are very few slips or misprints.

The first chapter of the work opens with an introductory section on behaviour in general, followed by an account of the more fundamental types of behaviour, viz. of cells and cell-aggregates, of plants and of reflex action, which latter is held to involve the existence of a differentiated nervous system. The chapter concludes with a section upon the evolution of consciousness, while the five succeeding chapters similarly include discussions upon the evolution, respectively, of consciousness, instinctive, intelligent, social and emotional behaviour. The last chapter is confined to the consideration of the evolution of animal behaviour. The principles which the author lays down for his guidance in the discussion of animal behaviour are the attempts to realise, in every case,

> "first, the nature of the animal under consideration; secondly, the conditions under which it is placed; thirdly, the manner in which the response is called forth by the circumstances; and fourthly, how far the behaviour adequately meets the essential conditions of the situation."

A rigid adherence to these wise principles, perhaps more than anything else, leads to a sense of confidence and security as we are guided through the intricacies of this most complex subject. Our gratitude is all the more real because of the difficulty and confusion which have been gratuitously introduced into the study of animal behaviour on account of the unfortunate conviction held by nearly every owner of a domestic pet that he, or even more frequently she, is intimately acquainted with the workings of its mind, and because of the unfortunate zeal with which hasty conclusions are spread abroad. May every lover of dog stories be induced to read the observations and conclusions on dog-behaviour (p. 141 *et sqq.*), and learn caution and restraint in interpretation. And caution is not needed less, but more, when the subjects of observation are farther removed from us in the zoological system, and combine far more wonderful instincts with a psychology more difficult to penetrate because far more remote and foreign to us. Maurice Maeterlinck's charmingly written book on the bee would have been more trustworthy if its author had received the advantage of Prof. Lloyd Morgan's friendly guidance in "Animal Behaviour" and his other kindred works. Many poetically expressed motives which are believed to bring about the wonderful instincts of the bees, and thoughts which are supposed to guide them, would thus have been advantageously omitted.

In speaking of the corporate behaviour of the cell-units of the higher animals it is well pointed out that the periods of apparent rest are in reality the periods of work during which are elaborated and stored up the unstable substances in preparation for the time of action;

> "just as the brilliant display of intellectual activity in a great orator is the result of the silent work of a lifetime, so is the physical manifestation of muscular power the result of the silent preparatory work of the muscle-cells."

In explaining this apparently wasteful and roundabout process the author points out that

> "only thus could the organs be enabled to act under the influence of stimuli and afford examples of corporate behaviour. They are like charged batteries ready to discharge under the influence of the slightest organic touch" (p. 23).

The adaptive behaviour of plants is illustrated by a few of the most remarkable examples, such as the fertilisation of *Vallisneria* and *Catasetum*, and we are led to the safe conclusion that the behaviour, beautiful and effective as it is, "does not afford any indication of the guidance of consciousness." Nowhere among plants do we meet with

> "so much as a hint of that profiting by individual experience which is the criterion of the effective presence of conscious guidance and control" (p. 31).

With the same wise caution the terms "discrimination" and "perception" are abandoned in favour of "differential reaction" in speaking of the movements of the tentacles of the sun-dew and of some of the lower animals. Thus all possibility of confusion with conscious choice is deliberately excluded.

In the brief section on the evolution of organic behaviour the author provisionally rejects the hypothesis of the hereditary transmission of acquired characters. He follows Osborn's convenient restriction of the term *modification* to the changes wrought by use or environment, and *variation* to the inherent differences which are due to the germ-cell. The distinction between these two classes of characters is carefully drawn and clearly illustrated, although the author omits to point out with sufficient clearness that the favourable *modification* is dependent no less than the favourable *variation* upon natural selection. The power of the organism to respond adaptively to environmental stimuli is probably an even higher effort of natural selection than that put forth in the production of some favourable inherent character which comes forth ready-made in the developing individual before any occasion for its use has arisen. The relation of body-cell to germ-cell in the struggle for existence and in evolution is clearly explained in an admirable comparison with the sterile and fertile individuals of the hive. By this means two complex and difficult subjects which have puzzled many a student of evolution are together rendered easy of comprehension.

The supposed cases of the instinctive hereditary fear of the dog by the kitten, the hawk by the young turkey, &c., are examined with much care in the chapter on consciousness. This examination and the result of the author's observations, together with those of Dr. Thorndike, Mr. W. H. Hudson and Mr. Frank Finn, lead to the conclusion that an inherited timidity ready to find instant expression at any unusual sight or sound has been erroneously interpreted as the hereditary fear of certain special enemies.

The stages of the evolution of consciousness are summed up in the statement that "in the first stage we have consciousness as accompaniment; in the second, consciousness as guide; in the third, consciousness as judge."

The term *instinct* is wisely limited to behaviour which is independent of experience. Acts which, at first voluntary, have become mechanical in the course of an individual life are regarded as *acquired habits*, the popular as well as the occasional scientific use of the term *instinctive* for this purpose being rejected. The definiteness of instinct is by no means held to imply that it is rigidly the same in all individuals of a species. Individual variation, bringing instinct under the sway of natural selection, is freely admitted, as it was by both Darwin and Wallace in their joint essay in 1858. The author's position in this respect is a return to the sound principles first laid down by the great originators of the theory of natural selection and a rejection of the attempt to improve upon these principles by a widely different, and for a time very popular, conception of instinct as due to the hereditary transmission of the results of intelligent learning, practice and habit, an interpretation which received a fatal blow in Weismann's critical attack upon the evidence in favour of the transmission of acquired characters in general. The whole question is discussed in an extremely fair and convincing manner in the section on the evolution of instinct (pp. 106–116).

The full definition of instinct which is here adopted closely follows Dr. and Mrs. Peckham's summary of the conclusions to which they were led by their deeply interesting study of the solitary wasps. Instinctive behaviour comprises

> "those complex groups of coordinated acts which are, on their first occurrence, independent of experience; which tend to the well-being of the individual and the preservation of the race; which are due to the co-operation of external and internal stimuli; which are similarly performed by all members of the same more or less restricted group of animals; but which are subject to variation, and to subsequent modification under the guidance of experience" (p. 71).

This is a definition which it is believed that Darwinian naturalists in general will be prepared to accept, as well as its application, *e.g.*, to the flight of birds where it is inferred

> "that instinct provides a general ground plan of behaviour which intelligent acquisition, by enforcing here and checking there, perfects and guides to finer issues" (p. 88).

The whole section upon the instinctive behaviour of young birds (pp. 84–98) abounds in original observations carefully carried out and interpreted with caution and judgment; they lead the author to the conclusion that experience is not hereditary.

The chapter on intelligent behaviour opens with the discussion of simple examples which lead to the statements that

> "whereas instinctive behaviour is prior to individual experience, intelligent behaviour is the outcome and product of such experience,"

and again,

> "instinct depends on how the nervous system is built through heredity; while intelligence depends upon how the nervous system is developed through use."

It may be doubted whether these sound and excellently expressed principles are applied with sufficient rigidity to the wonderful behaviour of insects. Thus Dr. and Mrs. Peckham's observation of the use of a stone by the solitary wasp *Ammophila urnaria* to beat down the earth with which she was filling up the entrance of her excavation is spoken of as "intelligent procedure," and is referred to even more strongly in the words, "here we have intelligent behaviour rising to a level to which some would apply the term rational." And yet it is in every way probable, in fact almost certain, that the whole behaviour of the *Ammophila* depended upon the manner in which "the nervous system was built through heredity," and that if the American naturalists had been fortunate enough to witness the first performance of the wasp it would have been found to be as perfect as any at any later period in its life. It may be questioned whether the use of the word "tool" is to be justified in speaking of the employment of the fragment of stone. A "tool" is not any object which may be used for a purpose, but an object fashioned for the purpose it is made to serve—a criticism which was suggested to the present writer by Prof. E. Ray Lankester in a conversation about this very observation. The use of decayed wood in the construction of combs by many wasps is probably a more complex piece of behaviour and more difficult to understand as a pure instinct than the behaviour of the *Ammophila*, and yet in this case the interpretation is certain. The present writer has seen the worker of a species of *Vespa* freshly emerged from the pupa, and the sole perfect insect upon the young comb (the queen mother having been previously killed) immediately seize upon the broken material of the comb and begin accurately and with exact precision to build up the thin and delicate sides of injured cells containing the living larvæ. We may feel confident from this fact that the worker possesses a nervous system which impels it from the first to seek the right material and do the highly complex work and enables it, without intelligence, at the outset to make use of wood of the right texture, dryness, &c. The use of stones, &c., for closing the mouth of the burrow is probably as ingrained in the nervous system of *Ammophila* as the use of wood in making cells is in the genus *Vespa*. In addition to the observation of Dr. and Mrs. Peckham, we have that of Dr. S. W. Williston upon another species, *A. yarrowi*, and still later, in the summer of 1899, the present writer and three others observed the same thing in a large species of *Ammophila* (propably *A. sabulosa*) at St. Helens, Isle of Wight. The latter observation followed very closely the account given by Dr. Williston. After the wasp had placed the larva in the burrow and, as was subsequently ascertained, laid an egg upon it, she seized, not a pebble, as in Dr. Williston's case, but a piece of peat or fibrous root, and forced it into the hole. The object of this was undoubtedly to act as a plug and prevent the earth from falling into the cell where the larva lay. Then earth was thrown upon the plug and after this an angular fragment of brick, which needed some effort to force into the tube ; then more earth and a final raking of the surface and scattering of twigs, &c., which obliterated all traces of disturbance. The piece of brick seemed to be in the nature of a burglar-proof door rather than a smoothing or pounding apparatus, in this particular instance. The soil was dry and sandy and perhaps did not need such special methods. At a previous stage the wasp acted as if with intelligence in dragging the larva into the burrow and then very rapidly out again in order to enlarge it still further. But this action is also in all probability the outcome of a nervous system built through heredity which impels the wasp to bury the larva in such a manner as to provide food and space for the wasp's growing offspring. The instinct requires a trial for its complete fulfilment. The evidence required to prove intelligent behaviour would be the observation that the wasp excavated more accurately and needed fewer trials with her prey, as, in the course of her life, "the nervous system developed through use." But any such evidence is as unlikely as that the other wasps should require experience to build their combs with exactness. We are dealing, in insects, with animals which commonly require to do various elaborate acts each but once in a lifetime, and thus always "prior to individual experience." The behaviour which leads to the production of an elaborate cocoon or the burial of a larva in its earthen cell is clearly instinctive, and the most convincing evidence is required in order to prove that certain insects which perform the same elaborate act many times in their lives are guided by anything except the compulsion of a "nervous system built through heredity."

The experiments and conclusions upon the intelligent behaviour of the higher vertebrates are most convincing. They are introduced by a clear statement of the essential nature of rational behaviour and the wide difference which separates it from intelligent behaviour. The attempt made by the author and Dr. Thorndike (pp. 153, 154) to set forth the mental condition of one of the higher animals is deeply interesting. Dr. Thorndike's "animal consciousness" sometimes felt during swimming will appeal to many as a very real experience, when

> "one feels the water, the sky, the birds above, but with no thoughts about them or memories of how they looked at other times, or æsthetic judgments about their beauty ; one feels no ideas about what movements he will make, but feels himself make them, feels his body throughout. Self-consciousness dies away. Social consciousness dies away. The meanings, and values, and connections of things die away. One feels sense-impressions, has impulses, feels the movements he makes ; that is all."

In the discussion upon the evolution of intelligent behaviour a most interesting and ingenious experiment made by the author is recorded. The close resemblance between specially protected species was explained by Fritz Müller in 1879 by the hypothesis that life was saved during the education of young and inexperienced enemies when the number of colours and patterns was few. Thus one appearance under this hypothesis may serve as a warning for many species, and it is not necessary for enemies to test more than a certain proportion of the species in order henceforth to avoid the whole. Prof. Lloyd Morgan made the following experiment in the attempt to discover whether the behaviour of a possible enemy is such as the Müllerian hypothesis assumes.

> "Strips of orange and black paper were pasted beneath glass slips, and on them meal moistened with quinine was placed. On other plain slips meal moistened with water was placed. The young birds [chicks] soon learnt to avoid the bitter meal, and then would not touch plain meal if it were offered on the banded slip. And these birds, save in two instances, refused to touch cinnabar caterpillars [with black and orange bands], which were new to their experience. They did not, like other birds, have to learn by particular trials that these caterpillars are unpleasant. Their experience had already been gained through the banded glass slips ; or so it seemed. I have also found that young birds who had learnt to avoid cinnabar caterpillars left wasps untouched. Such observations must be repeated and extended. But they seem to show that one aspect of the Müllerian theory is not without some facts in support of it ; and, so far as they go, they afford evidence that black and orange banding, irrespective of particular form, may constitute a guiding generic feature in the conscious situation."

This evidence is of especial interest to the student of mimicry, particularly to the present writer, who ventured to suggest (*Proc.* Zool. Soc., 1887, p. 235) a Müllerian association between the cinnabar larva and the wasp.

In the account of "Müllerian mimicry" (p. 164) the hasty reader might infer that Dr. Fritz Müller had depended on Mr. Frank Finn's observations upon birds, observations made after Müller's death and about twenty years after the publication of his hypothesis. A reference to the publication, from which a sentence is quoted, would prevent any possible misconception.

Want of space prevents any discussion of the remaining chapters, which are full of interest. Prof. Groos' theory of animal play as a preparation for the serious business of life is explained in a luminous manner (pp. 248 *et sqq.*), so that the reader will gain a perfectly clear idea of one of the most important of recent contributions to Darwinian theory. Dr. Louis Robinson published an outline of this idea the year before Prof. Groos' work appeared. Thus in the Reports of the British Association for 1894, p. 778, the abstract of Dr. Robinson's paper to Section H contains these words :—

> "It is found that in young apes, puppies, and other like animals, the most ticklish regions correspond to the most vulnerable spots in a fight. In the mock fights of immaturity, skill in defending these spots is attained."

And Prof. Lloyd Morgan himself had written still earlier on the same subject (*Atalanta*, January 1889).

The discussion of animal courtship and its psychological analysis constitute one of the most interesting parts of the work. The author's conclusions will, it is believed, be fully accepted by those who follow the Darwinian theory of sexual selection. The more exuberant phraseology of previous writers on the same subject was probably never intended to convey anything very different from the conduct and climax of courtship as here described. But it has required the assistance of one trained both as psychologist and as zoologist to expound the subject so that misapprehension is well-nigh impossible. The author's twofold capacity in dealing with subjects which require to be looked at from very different points of view, as expressed in the title of this review, renders, not only the discussion of courtship, but the whole work, of great value to students in two very different yet closely related fields of knowledge.

E. B. P.

## *CELLULOSE.*

*Researches on Cellulose from* 1895–1900. By Cross and Bevan. Pp. vii + 180. (London: Longmans, Green and Co.) Price 6*s*. net.

VEGETABLE substances or products of vegetable origin have always had a peculiar fascination to chemists, not only because of the light which may be thrown on general chemical science, should methods of synthesis be discovered, but often because, as was the case with alizarin and more recently with indigo, huge industrial applications may be the outcome of this branch of research. Further, researches are often conducted with the hope that we may be enabled to reveal some of the hidden secrets of nature, as, for example, how the elements which are assimilated by plants in the form of the simplest of compounds become ultimately converted into some of the most complex combinations known to chemists.

In "Researches on Cellulose," by Cross and Bevan, we are dealing with a class of substances which may be said to form the structural basis of all natural organic substances. A very large amount of research has been carried out with the object of ascertaining the molecular configuration of the celluloses, but it cannot be said, up to the present, to have thrown very much light upon the ultimate structure of these substances. If the researches on cellulose have not been very fruitful in this direction, they have, on the other hand, been of enormous industrial importance. A very much larger number of industries are concerned with "cellulose" in one form or another than those who have not studied the subject are probably aware. We have only to think of the colossal scale upon which paper is manufactured and the employment of nitrocelluloses in the manufacture of smokeless powder to realise the far-reaching applications of cellulose.

The authors state in their preface that the present volume is intended as a supplement to the work which they published six years ago. The book is more or less in the form of abstracts of researches which have been published since 1895, but it also contains results of the authors' own investigations which have not previously been recorded. The chemistry of cellulose has attracted considerable attention abroad, but in England, with a few exceptions, it has been almost neglected. Messrs. Cross and Bevan call attention to this neglect, and remark that:—

> "To the matter of the present volume, excluding our own investigations, there are but *two* contributions from English laboratories. We invite the younger generation of chemists to measure the probability of finding a working career in connection with the cellulose industry."

Considering the enormous importance, the vast extent and the almost unlimited possibilities of the cellulose industry, we trust that this invitation will meet with a hearty response. It is remarkable that in text-books on chemistry, with the exception of technical works—which in this country are few and far between—the subject of cellulose takes a very back-seat. But perhaps we can hardly blame the authors of such works, whose intention, generally speaking, is to teach the theory of organic chemistry. When very little is known about the theory of the subject, it is not unnatural that very little should be said about it.

The book commences with a general introduction, in which the authors reply to some of the criticisms of their previous work. They then explain in detail the plan of the book, and consider the following classification to be the most natural.

> "Cellulose is in the first instance a *structure*, and the anatomical relationships supply a certain basis of classification. Next, it is known to us and is defined by the negative characteristics of resistance to hydrolytic actions and oxidations. These are dealt with in order of their intensity. Next we have the more positive definition by ultimate products of hydrolysis, so far as they are known, which discloses more particularly the presence of a greater or less proportion of furfural-yielding groups."

Until more definite knowledge of the ultimate structure of the various celluloses is known, this method of classification seems to be about the best.

The section on cellulose esters is extremely good, the paragraphs on the cellulose benzoates, which the authors have prepared by first treating fibrous cellulose (cotton) with a 10 per cent. solution of caustic soda and then with benzoyl chloride, being exceptionally interesting. It is rather interesting to note, by the way, that the dibenzoate is devoid of all structure, and is therefore readily recognised from the fibrous monobenzoate.

Under cellulose acetates the authors correct the statement made in their previous work that "on boiling cotton with acetic anhydride and sodium acetate, no reaction occurs." At the boiling point of the anhydride an ester is obtained, although without any apparent structural alteration of the fibre. Under esters is also included inorganic esters—the nitro-esters, which are of such importance in the manufacture of cordite, ballistite, "smokeless powders," &c.

The articles on *lustra-cellulose* or artificial silk will interest many, but the authors protest against the term artificial silk, and suggest that the term "*lustra-cellulose*" should be employed. Considering the manner in which the term "artificial" is so often misused, we quite agree. Inform the public that an article is artificial and they at once brand it as "false" or as a "substitute." In the